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(11) **EP 0 750 603 B1**

(12)

## EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention  
of the grant of the patent:

19.05.1999 Bulletin 1999/20

Opp Feb 19, 2000

(21) Application number: 95910673.3

(22) Date of filing: 13.03.1995

(51) Int Cl.<sup>6</sup>: **C07C 51/48, C07C 59/08,  
C07C 59/265**

(86) International application number:  
**PCT/GB95/00535**

(87) International publication number:  
**WO 95/25081 (21.09.1995 Gazette 1995/40)**

### (54) A PROCESS AND EXTRACTANT COMPOSITION FOR EXTRACTING ACIDS

VERFAHREN UND EXTRAKTIONSMITTELZUSAMMENSETZUNG FÜR EXTRAKTION DER  
SÄUREN

PROCEDE ET COMPOSITION D'EXTRACTION DESTINES A EXTRAIRE DES ACIDES

(84) Designated Contracting States:  
**AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL  
PT SE**

(30) Priority: 16.03.1994 IL 10900394

(43) Date of publication of application:  
02.01.1997 Bulletin 1997/01

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LLX. III. A 'TEMPERATURE SWING' BASED  
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Ownership?

pressure are so chosen that the amine remains in the organic phase. In many cases the extraction can be carried out at or near room temperature, and the stripping operation at a temperature of about 20 to 40 degrees (Centigrade) above room temperature. As a rule, the stripping operation is the more effective, the higher the stripping temperature, but the extraction and stripping temperatures will be selected in individual cases in accordance with practical factors, such as corrosion-resistance and the costs of the equipment, costs of heating and cooling of the streams of the acid solution, the extract and the extractant, the required concentration of stripped acid, etc.

"If the aqueous liquid used for stripping the extract is water, the back-extract is an aqueous solution of the free acid. If desired, the back-extracting operation may be so conducted that the back-extract is an aqueous solution of a salt of the extracted acid. For example, back-extraction with an aqueous alkali metal (in this context "alkali metal" includes ammonium) hydroxide solution yields an aqueous solution of the corresponding alkali metal salt of the extracted acid. Or the aqueous back-extracting liquid may be, for example, an alkali metal chloride solution. In this case, too, the back-extract contains the corresponding alkali metal salt of the extracted acid while the amine in the extractant is converted into its hydrochloride. This will thus have to be decomposed, e.g. by treatment with calcium hydroxide, for reconstituting the extractant. Sometimes it is advantageous to perform first a back-extraction with water in order to recover the major part of the acid in the free state. The residue of acid remaining in the solvent extract can then be back-extracted with an alkali metal hydroxide or salt solution.

"The most favourable selection of the temperature of the extracting operation and of the compositions of the extractant, as regards both the amine and the solvent, will also be determined according to the given condition of particular cases, e.g., the kind of acid, its concentration in the original aqueous solution, the impurities present in that solution. The major aim in both the extracting and stripping operations will be to achieve as favourable a distribution coefficient as possible for the distribution of the acid between the aqueous and organic phases. In the extraction operation, this has to be in favour of the extractant; in the stripping operation, in favour of the aqueous phase."

[0013] In the Baniel, et al., process, back-extraction is performed at a temperature higher than that of the extraction. For certain acids, they have shown efficient extraction at about room temperature. Back-extraction at about 100°C provides for a back extract, the concentration of which is similar to, or even higher than, that of the feed. A major part of citric acid production in the world is based on this process, using tridodecyl amine as the primary extractant and 1-octanol as the enhancer [Kirk-Othmer, Encyclopedia of Chemical Technology, 4th Ed., Vol. 6, p. 364].

[0014] Similarly, Marrs et al. (AT-C-379-582) describes a method of extraction, wherein the back-extraction process involves use of a stripping acid.

[0015] Extractants comprising relatively strong amines as the primary extractant, show nearly no temperature sensitivity on the efficiency of extracting strong mineral acids. It was, however, found that relatively weak amines do show such effect. An example of such weak amines is the sterically-hindered, branched chain amines with branching on a carbon close to the nitrogen atom [Eyal, et al., *Solvent Extraction and Ion Exchange*, Vol. 9, pp. 195-236 (1991)]. These amines are weaker by more than two orders of magnitude than straight chain amines, and weaker than branched chain amines with branching far from the nitrogen atom. Such amines are too weak to extract most weak acids and are not suitable for use as primary extractants in the present invention. For simplicity of language, the term "branched chain amines" will be used here just for sterically hindered, relatively weak amines with branching close to the nitrogen atom.

[0016] Branched chain amines are too weak to extract many of the carboxylic acids, particularly hydroxycarboxylic acids. Straight chain amines are much more efficient, but complete extraction without resorting to high cooling costs requires the use of extraction enhancer. This is particularly true for extraction from dilute feed solutions. Yet, the stronger is the enhancer and the higher its contents, the lower is the sensitivity of extraction efficiency to temperature. Thus, amine-based extractants, comprising relatively strong enhancers at high proportions of enhancers, show high efficiency in extraction, but lose most of the advantage in back-extraction at higher temperature, according to U.S. Patent 4,275,234.

[0017] According to the known practice, there have been suggested four main options, as well as variations and combinations thereof:

- a) Use of a weak enhancer or a strong enhancer, at a minimal concentration required for extraction completion (non-optimal extractant composition in extraction, high extractant volume, many stages in extraction). This option was chosen for the citric acid production.
- b) Increase the temperature span between extraction and back-extraction (expensive cooling and high viscosity in extraction, and expensive heating and thermal degradation in back-extraction).
- c) Distill at least part of the enhancer from the extract prior to back-extraction (high energy cost, limitation to volatile enhancers that in most cases have relatively high solubility in the aqueous streams, requiring additional recovery operations).
- d) Add to the extract an a-polar solvent that acts as extraction suppressor, and removal of this solvent prior to the use of the regenerated extractant (low efficiency, high energy cost).

[0018] In contradistinction to the above options, a first aspect of the present invention is based on the discovery that polar organic compounds with steric hinderance of the polar group have, at about ambient temperature, an enhancement effect similar to that of similar non-hindered compounds, but lower enhancement effect at elevated temperature. As a result, efficient extraction is achievable using amine-based extractants at about ambient temperature, in combination with convenient amounts of enhancer, while efficient back-extraction is achieved at elevated temperature, without resorting to unduly high temperatures in back-extraction and/or high energy-consuming removal of extractant components, either prior to back-extraction or after it.

[0019] Furthermore, it is well known that enhancer-containing extractants provide for more efficient extraction, but at the cost of reduced temperature sensitivity of the extracting power. The advantage of enhancer application in the extraction may be out-balanced by the reduced temperature sensitivity. Thus, for extraction of an acid from an aqueous feed of a relatively high acidity, particularly if incomplete extraction can be tolerated, non-enhanced (or slightly enhanced) extractants are preferred. On the other hand, in extraction from dilute aqueous solutions of acids, and particularly in extraction from aqueous solutions of relatively high pH, an enhanced extractant is essential for efficient extraction (alternatively, a non-enhanced, very strong amine can be used as a primary extractant, but stripping is impractical for such extractants).

[0020] Lactic acid production by fermentation is product-inhibited. The pH in the fermentation liquor should, therefore, be maintained by the addition of a base, at a pH of about 5, and preferably above 6. At this pH, nearly all the lactic acid ( $pK_a = 3.86$ ) is converted to its salt form, and acid activity is negligible. No extraction of lactic acid is observed on contacting this solution with a tertiary amine-comprising extractant. In the presence of a weak acid and/or pressurized  $CO_2$ , some extraction takes place. Yet, it was found that in order to reach suitable extraction at a reasonable  $CO_2$  pressure, the extractant should be enhanced by a strong enhancer, i.e., by a polar, and preferably protic, organic enhancing compound. It was surprisingly found that sterically hindered enhancers, which facilitate the temperature-sensitive stripping operation, are strong enough enhancers to augment the extraction of an acid from feed solutions at a pH higher than the  $pK_a$ .

[0021] Thus, the present invention now provides a process for the recovery of a water-soluble carboxylic or mineral acid having a  $pK_a$  higher than 2, from an aqueous feed solution containing said acid or a salt thereof, comprising extracting said acid with a water-immiscible extractant composition, said composition comprising (a) at least one secondary or tertiary alkyl amine, in which the aggregate number of carbon atoms is at least 20, as a primary extractant; and (b) a sterically hindered, polar, organic compound, having at least 5 car-

bon atoms, a basicity weaker than that of said primary extractant, and temperature-sensitive, extraction-modifying properties; separating the acid containing said extractant and subjecting it to a stripping operation at a temperature of at least  $20^\circ C$  higher than the temperature at which said extraction is carried out, wherein said sterically hindered, polar, organic compound both modifies the extracting power of said primary extractant composition and facilitates said temperature-sensitive stripping operation.

[0022] In preferred embodiments of the present invention, said sterically hindered, polar, organic compound is selected from the group consisting of alkanols, carboxylic acids, tertiary amines, or trialkylphosphates, having a sterically hindering substituent attached to the carbon carrying said polar group, or to a carbon which is alpha, beta, or gamma to said carbon.

[0023] Depending on the desired process and the nature of the acid or salt and the primary extractant, said sterically hindered, polar, organic compound can be an extraction inhibitor, functioning, e.g., as a weak inhibitor at low temperature, and as a stronger inhibitor at higher temperature; or as an extraction enhancer having stronger extraction-enhancing activities at low temperatures than at higher temperatures. Said stripping or back-extraction operation can be effected with an aqueous solution, or even by distillation. In the latter case, the compound used will have a boiling point at about at least  $10^\circ$  above the stripping temperature at the stripping operating pressure.

[0024] Polar, and particularly protic, organic compounds act as enhancers of acid extraction by amines, due to their ability to solvate the amine acid ion pair formed on such extraction. Organic compounds suitable for use as enhancers in the present invention have at least one such polar or protic group, the solvating properties of which are hindered by the structure of the molecule. The polar group is preferably a hydroxyl, an ester, an aldehyde, a carboxyl, a ketone, or an amine, or said polar group can comprise a halogen, sulfur, nitrogen or phosphate atom. The hindrance can be achieved through substitution of a hydrogen atom in the alkyl chain by an aliphatic group, i.e., branching on the carbon atom carrying the polar group, or on a carbon which is alpha, beta, or gamma to said carbon.

[0025] The enhancer should be a weaker base than the amine used as the primary extractant in the extractant composite. On equilibrating it with a 0.1M aqueous HCl solution in a proportion that provides for enhancer to HCl molar ratio of 2, the aqueous phase pH will remain below 2. On a similar equilibration, with the amine acting by itself as the non-enhanced extractant, the pH of the aqueous phase increases to about 2.5 or higher.

[0026] The extractant comprises at least one secondary or tertiary alkylamine, the aggregate number of carbon atoms of which is at least 20, as the primary extractant. Particularly suitable amines are the commercially available trioctyl, tricaprylyl, tridecyl, and tridodecyl

amines.

[0027] In addition to the primary extractant and the sterically-hindered, polar, organic enhancer compound, the extractant may comprise a water-immiscible, polar or nonpolar solvent, for example, aliphatic or aromatic hydrocarbon, hydrocarbons carrying nitro or halo substituents, and alcohols.

[0028] In preferred embodiments of the present invention, said sterically hindered, polar, extraction-enhancing compound is selected from the group consisting of secondary or tertiary alkanols, tris-2-ethylhexyl amine, and tris-2-ethylhexyl phosphate.

[0029] As indicated, the present improved process is especially applicable to recovering hydroxycarboxylic acids such as citric acid and lactic acid, and can be used to modify and replace the commercially-used process for the preparation of citrus acid, e.g., by replacing 1-octanol in the extractant composition with a sterically hindered, polar, organic compound having at least 5 carbon atoms and a basicity weaker than that of said primary extractant, as taught by the present invention.

[0030] In another preferred embodiment of the present invention, the process is carried out with an aqueous feed solution having a pH higher than the pKa of the acid to be extracted. Preferably, the pH should be higher by at least one unit than the pH of said acid.

[0031] As is known, when the pH of the feed solution is equal to the pKa of the acid to be extracted, about 50% of the acid is neutralized; while when the pH is one unit higher than the pKa of the acid to be extracted, about 90% of said acid is neutralized.

[0032] Therefore, as explained hereinabove, the present invention could be used to recover lactic acid, said extraction being performed in the presence of CO<sub>2</sub> and said primary extractant being a tertiary alkyl amine.

[0033] The present invention also provides an extractant composition for use in a process for the recovery of a water-soluble, carboxylic or mineral acid having a pKa higher than 2, from an aqueous feed solution containing said acid or a salt thereof, said composition comprising (a) at least one secondary or tertiary alkyl amine, in which the aggregate number of carbon atoms is at least 20, as a primary extractant; and (b) a sterically hindered, polar, organic compound having at least 5 carbon atoms, a basicity weaker than that of said primary extractant, and temperature-sensitive, extraction-modifying properties,

wherein said sterically hindered, polar, organic compound is selected from the group consisting of alkanols, carboxylic acids, tertiary amines, or trialkylphosphates having a sterically hindering substituent attached to the carbon carrying said polar group, or to a carbon which is alpha, beta, or gamma to said carbon.

[0034] In a preferred embodiment of the present invention, particularly if the pH of the aqueous feed is higher than the pKa of said acid, the extraction can be performed in the presence of another weak acid, or in the presence of CO<sub>2</sub>.

[0035] While the invention will now be described in connection with certain preferred embodiments in the following examples so that aspects thereof may be more fully understood and appreciated, it is not intended to limit the invention to these particular embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the scope of the invention as defined by the appended claims. Thus, the following examples which include preferred embodiments will serve to illustrate the practice of this invention, it being understood that the particulars shown are by way of example and for purposes of illustrative discussion of preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of formulation procedures as well as of the principles and conceptual aspects of the invention.

## EXAMPLES

[0036] The temperature sensitivity of the extracting power of the extractant composition is shown by comparing distribution co-efficients - D (extracted acid concentration in the organic phase in equilibrium, divided by its concentration in the aqueous phase in equilibrium). Temperature sensitivity is reflected in D decrease, with temperature elevation. A higher  $D_{RT}/D_T$  ratio indicates higher temperature sensitivity (D at ambient temperature, divided by D at an elevated temperature T).

[0037] Table 1 summarizes  $D_{RT}/D_{95^\circ C}$  for lactic acid extraction by extractants comprising 50% w/w Alamine 336 (tricapryl amine produced by Henkel), 20% W/W enhancer, and 30% of a low aromatics kerosene. Acid concentration in equilibrium aqueous phases, at both temperatures, was 0.5 mol/kg.

TABLE 1

Enhancer	$D_{RT}/D_{95^\circ C}$
1-Octanol	2.3
3-ethyl-3-pentanol	4.4
2,4-dimethyl-3-pentanol	3.3
6-undecanol	4.2
tris-(2-ethylhexyl)amine	8.5
tris-(2-ethylhexyl) phosphate	7.5

[0038] These results indicate that extractant compositions containing sterically hindered, polar, organic enhancers show higher temperature sensitivity than n-octanol-containing extractant compositions. For most of the enhancers in Table 1, enhancement at ambient temperature was similar to that of n-octanol.

[0039] Table 2 summarizes  $D_{RT}/D_{95^\circ C}$  for citric acid extraction by extractants comprising 55% Alamine 304 (tridodecyl amine produced by Henkel), 6% enhancer, and 39% low aromatics kerosene. Citric acid concentra-

tion in equilibrium aqueous phases, at both temperatures, was 0.5 mol/kg.

TABLE 2

Enhancer	$D_{RT}/D_{95^{\circ}C}$
n-Octanol	2.0
4-methyl-2-pentanol	2.4
3-ethyl-3-pentanol	4.3

[0040] It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative examples and that the present invention may be embodied in other specific forms without departing from the essential attributes thereof, and it is therefore desired that the present embodiments and examples be considered in all respects as illustrative and not restrictive, reference being made to the appended claims, rather than to the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

#### Claims

1. A process for the recovery of a water-soluble carboxylic or mineral acid having a pKa higher than 2, from an aqueous feed solution containing said acid or a salt thereof, comprising extracting said acid with a water-immiscible extractant composition, said composition comprising:

- (a) at least one secondary or tertiary alkyl amine, in which the aggregate number of carbon atoms is at least 20, as a primary extractant; and
- (b) a sterically hindered, polar, organic compound having at least 5 carbon atoms, a basicity weaker than that of said primary extractant, and temperature-sensitive, extraction-modifying properties;

separating the acid containing said extractant and subjecting it to a stripping operation at a temperature of at least 20°C higher than the temperature at which said extraction is carried out,

wherein said sterically hindered, polar, organic compound both modifies the extracting power of said primary extractant composition and facilitates said temperature-sensitive stripping operation.

2. A process according to claim 1, wherein said sterically hindered, polar, organic compound is an extraction enhancer.
3. A process according to claim 1, wherein said sterically

ally hindered, polar, organic compound is selected from the group consisting of alkanols, carboxylic acids, tertiary amines, or trialkylphosphates having a sterically hindering substituent attached to the carbon carrying said polar group, or to a carbon which is alpha, beta, or gamma to said carbon.

4. A process according to claim 3, wherein said substituent is an aliphatic group.

5. A process according to claim 2, wherein said sterically hindered, polar, organic compound is selected from the group consisting of secondary or tertiary alkanols, tris-2-ethylhexyl amine, and tris-2-ethylhexyl phosphate.

6. A process according to claim 1, wherein the recovered acid is a hydroxycarboxylic acid.

7. A process according to claim 6, wherein the recovered acid is citric acid.

8. A process according to claim 6, wherein the recovered acid is lactic acid.

9. A process according to claim 1, wherein the aqueous solution of said acid or its salt is obtained by fermentation.

10. A process according to claim 1, wherein the extraction is performed in the presence of another weak acid.

11. A process according to claim 1, wherein the extraction is performed in the presence of CO<sub>2</sub>.

12. A process according to claim 1, wherein the boiling point of said compound is at least 10°C above the stripping temperature at the stripping operating pressure.

13. A process according to claim 1, wherein said stripping operation is effected with an aqueous liquid.

14. A process according to claim 1, wherein said stripping operation is effected by distillation.

15. A process according to claim 1, wherein said aqueous feed solution is at a pH higher than the pKa of said acid.

16. A process according to claim 1, wherein the pH of said aqueous feed solution is higher by at least one unit than the pKa of said acid.

17. A process according to claim 16, wherein said acid is lactic acid.

18. A process according to claim 17, wherein said extraction is performed in the presence of CO<sub>2</sub>, and wherein said primary extractant is a tertiary alkyl amine.

19. An extractant composition for use in a process for the recovery of a water-soluble, carboxylic or mineral acid having a pKa higher than 2, from an aqueous solution containing said acid or a salt thereof, said composition comprising:

- a) at least one secondary or tertiary alkyl amine in which the aggregate number of carbon atoms is at least 20, as a primary extractant; and
- b) a sterically hindered, polar, organic compound having at least 5 carbon atoms, a basicity weaker than that of said primary extractant, and temperature-sensitive, extraction-modifying properties,

wherein said sterically hindered, polar, organic compound is selected from the group consisting of alkanols, carboxylic acids, tertiary amines, or trialkylphosphates having a sterically hindering substituent attached to the carbon carrying said polar group, or to a carbon which is alpha, beta, or gamma to said carbon.

20. An extractant composition as claimed in claim 19, further comprising a water-immiscible, organic solvent.

#### Patentansprüche

1. Verfahren zur Gewinnung einer wasserlöslichen Carbon- oder Mineralsäure mit einem pKa-Wert, der höher ist als 2, aus einer wäßrigen Beschickungslösung, enthaltend die Säure oder ein Salz davon, umfassend das Extrahieren der Säure mit einer mit Wasser nicht mischbaren Extraktionsmittelzusammensetzung, wobei die Zusammensetzung umfaßt:

- (a) mindestens ein sekundäres oder tertiäres Alkylamin, in welchem die Aggregatzahl der Kohlenstoffatome mindestens 20 beträgt, als primäres Extraktionsmittel; und
- (b) eine sterisch gehinderte, polare, organische Verbindung mit mindestens 5 Kohlenstoffatomen, einer Basizität, die schwächer ist als die des primären Extraktionsmittels, und temperaturempfindlichen, die Extraktion modifizierenden Eigenschaften;

das Abtrennen der Säure, enthaltend das Extraktionsmittel, und Unterwerfen derselben einem Arbeitsgang der Austreibung bei einer Temperatur,

die mindestens 20°C höher ist als die Temperatur, bei der die Extraktion ausgeführt wird,

wobei die sterisch gehinderte, polare, organische Verbindung sowohl die Extraktionskraft der primären Extraktionsmittelzusammensetzung modifiziert als auch den temperaturempfindlichen Arbeitsgang der Austreibung erleichtert.

2. Verfahren nach Anspruch 1, wobei die sterisch gehinderte, polare, organische Verbindung ein Extraktionsverbesserer ist.

3. Verfahren nach Anspruch 1, wobei die sterisch gehinderte, polare, organische Verbindung ausgewählt ist aus der Gruppe, bestehend aus Alkanolen, Carbonsäuren, tertiären Aminen oder Trialkylphosphaten mit einem sterisch hindernenden Substituenten, gebunden an den Kohlenstoff, der die polare Gruppe trägt, oder an einen Kohlenstoff, der in alpha-, beta- oder gamma-Stellung zu diesem Kohlenstoff ist.

4. Verfahren nach Anspruch 3, wobei der Substituent eine aliphatische Gruppe ist.

5. Verfahren nach Anspruch 2, wobei die sterisch gehinderte, polare, organische Verbindung ausgewählt ist aus der Gruppe, bestehend aus sekundären oder tertiären Alkanolen, Tris-2-ethylhexylamin und Tris-2-ethyl hexyl phosphat.

6. Verfahren nach Anspruch 1, wobei die gewonnene Säure eine Hydroxycarbonsäure ist.

7. Verfahren nach Anspruch 6, wobei die gewonnene Säure Zitronensäure ist.

8. Verfahren nach Anspruch 6, wobei die gewonnene Säure Milchsäure ist.

9. Verfahren nach Anspruch 1, wobei die wäßrige Lösung der Säure oder ihres Salzes durch Fermentation erhalten wird.

10. Verfahren nach Anspruch 1, wobei die Extraktion in Anwesenheit einer anderen schwachen Säure durchgeführt wird.

11. Verfahren nach Anspruch 1, wobei die Extraktion in Anwesenheit von CO<sub>2</sub> durchgeführt wird.

12. Verfahren nach Anspruch 1, wobei der Siedepunkt der Verbindung bei dem Arbeitsdruck der Austreibung mindestens 10°C über der Temperatur der Austreibung liegt.

13. Verfahren nach Anspruch 1, wobei der Arbeitsgang der Austreibung mit einer wäßrigen Flüssigkeit be-

werkstellig wird.

14. Verfahren nach Anspruch 1, wobei der Arbeitsgang der Austreibung durch Destillation bewerkstelligt wird.

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15. Verfahren nach Anspruch 1, wobei die wäßrige Beschickungslösung einen pH-Wert hat, der höher ist als der pKa-Wert der Säure.

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16. Verfahren nach Anspruch 1, wobei der pH-Wert der wäßrigen Beschickungslösung um mindestens eine Einheit höher ist als der pKa-Wert der Säure.

17. Verfahren nach Anspruch 16, wobei die Säure Milchsäure ist.

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18. Verfahren nach Anspruch 17, wobei die Extraktion in Anwesenheit von CO<sub>2</sub> durchgeführt wird und wobei das primäre Extraktionsmittel ein tertiäres Alkylamin ist.

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19. Extraktionsmittelzusammensetzung zur Verwendung in einem Verfahren zur Gewinnung einer wasserlöslichen Carbon- oder Mineralsäure mit einem pKa-Wert, der höher ist als 2, aus einer wäßrigen Lösung, enthaltend die Säure oder ein Salz davon, wobei die Zusammensetzung umfaßt:

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(a) mindestens ein sekundäres oder tertiäres Alkylamin, in welchem die Aggregatzahl der Kohlenstoffatome mindestens 20 beträgt, als primäres Extraktionsmittel; und

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(b) eine sterisch gehinderte, polare, organische Verbindung mit mindestens 5 Kohlenstoffatomen, einer Basizität, die schwächer ist als die des primären Extraktionsmittels, und temperaturempfindlichen, die Extraktion modifizierenden Eigenschaften;

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wobei die sterisch gehinderte, polare, organische Verbindung ausgewählt ist aus der Gruppe, bestehend aus Alkanolen, Carbonsäuren, tertiären Aminen oder Trialkylphosphaten mit einem sterisch hindernden Substituenten, gebunden an den Kohlenstoff, der die polare Gruppe trägt, oder an einen Kohlenstoff, der in alpha-, beta- oder gamma-Stellung zu diesem Kohlenstoff ist.

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20. Extraktionsmittelzusammensetzung nach Anspruch 19, weiterhin umfassend ein mit Wasser nicht mischbares, organisches Lösungsmittel.

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## Revendications

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1. Procédé de récupération d'un acide carboxylique ou d'un acide minéral soluble dans l'eau possédant

un pKa supérieur à 2, à partir d'une solution aqueuse d'alimentation contenant ledit acide ou un sel de celui-ci, consistant à extraire ledit acide avec une composition de solvant d'extraction non miscible dans l'eau, ladite composition comprenant:

(a) au moins une amine d'alkyle secondaire ou tertiaire, dans laquelle le nombre total d'atomes de carbone est au moins égal à 20, en tant que solvant d'extraction primaire; et

(b) un composé organique, polaire, à encombrement stérique, possédant au moins 5 atomes de carbone, une basicité plus faible que celle dudit solvant d'extraction primaire et des propriétés modifiant l'extraction, sensibles à la température;

à séparer l'acide contenant ledit solvant d'extraction et à le soumettre à une opération de stripping à une température supérieure d'au moins 20°C à la température à laquelle ladite extraction est réalisée,

dans lequel ledit composé organique, polaire, à encombrement stérique modifie à la fois la puissance d'extraction de ladite composition de solvant d'extraction primaire et facilite ladite opération de stripping sensible à la température.

2. Procédé suivant la revendication 1, dans lequel ledit composé organique, polaire, à encombrement stérique est un activateur d'extraction.

3. Procédé suivant la revendication 1, dans lequel ledit composé organique, polaire, à encombrement stérique est choisi parmi le groupe composé d'alcanols, d'acides carboxyliques, d'amines tertiaires ou de phosphates de trialkyle contenant un substituant à encombrement stérique fixé sur le carbone supportant ledit groupe polaire ou sur un carbone qui est en position alpha, bêta ou gamma par rapport audit carbone.

4. Procédé suivant la revendication 3, dans lequel ledit substituant est un groupe aliphatique.

5. Procédé suivant la revendication 2, dans lequel ledit composé organique, polaire, à encombrement stérique est choisi parmi le groupe composé d'alcanols secondaires ou tertiaires, de la tris-2-éthylhexylamine et du tris-2-éthylhexylphosphate.

6. Procédé suivant la revendication 1, dans lequel l'acide récupéré est un acide hydroxycarboxylique.

7. Procédé suivant la revendication 6, dans lequel l'acide récupéré est de l'acide citrique.

8. Procédé suivant la revendication 6, dans lequel

l'acide récupéré est de l'acide lactique.

9. Procédé suivant la revendication 1, dans lequel la solution aqueuse dudit acide ou de son sel est obtenue par fermentation. 5
10. Procédé suivant la revendication 1, dans lequel l'extraction est effectuée en présence d'un autre acide faible. 10
11. Procédé suivant la revendication 1, dans lequel l'extraction est effectuée en présence de  $\text{CO}_2$ .
12. Procédé suivant la revendication 1, dans lequel le point d'ébullition dudit composé est d'au moins  $10^\circ\text{C}$  au-dessus de la température de strippage à la pression opératoire de strippage. 15
13. Procédé suivant la revendication 1, dans lequel ladite opération de strippage est effectuée avec un liquide aqueux. 20
14. Procédé suivant la revendication 1, dans lequel ladite opération de strippage est effectuée par distillation. 25
15. Procédé suivant la revendication 1, dans lequel ladite solution aqueuse d'alimentation se trouve à un pH qui est supérieur au  $\text{pK}_a$  dudit acide. 30
16. Procédé suivant la revendication 1, dans lequel le pH de ladite solution aqueuse d'alimentation est supérieur d'au moins une unité au  $\text{pK}_a$  dudit acide.
17. Procédé suivant la revendication 16, dans lequel ledit acide est de l'acide lactique. 35
18. Procédé suivant la revendication 17, dans lequel ladite extraction est réalisée en présence de  $\text{CO}_2$  et dans lequel ledit solvant d'extraction primaire est une amine d'alkyle tertiaire. 40
19. Composition de solvant d'extraction destinée à une utilisation dans un procédé de récupération d'un acide carboxylique ou d'un acide minéral soluble dans l'eau possédant un  $\text{pK}_a$  supérieur à 2, à partir d'une solution aqueuse contenant ledit acide ou un sel de celui-ci, ladite composition comprenant: 45
  - (a) au moins une amine d'alkyle secondaire ou tertiaire, dans laquelle le nombre total d'atomes de carbone est au moins égal à 20, en tant que solvant d'extraction primaire; et 50
  - (b) un composé organique, polaire, à encombrement stérique, possédant au moins 5 atomes de carbone, une basicité plus faible que celle dudit solvant d'extraction primaire et des propriétés modifiant l'extraction et sensibles à 55

la température,

dans lequel ledit composé organique, polaire, à encombrement stérique est choisi parmi le groupe composé d'alcanols, d'acides carboxyliques, d'amines tertiaires ou de phosphates de trialkyle contenant un substituant à encombrement stérique fixé sur le carbone supportant ledit groupe polaire ou sur un carbone qui est en position alpha, bêta ou gamma par rapport audit carbone.

20. Composition de solvant d'extraction suivant la revendication 19, comprenant en outre un solvant organique, non miscible dans l'eau.